PART III: APPENDICES

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APPENDIX A:

EXAMPLE OF AN ECOLOGICAL ASSESSMENT WORK PLAN

WORK PLAN FOR CONDUCTING AN ECOLOGICAL RISK ASSESSMENT AT THE WASHBONE SITE, BURKE COUNTY, GEORGIA[1]

Prepared for:

U. S. Department of Energy
Washbone Site Remedial Action Project
Waynesboro, Georgia

May 1993

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[1] "Washbone" is a fictitious site. Information and format from several work plans in various draft stages have been used (i.e., modified or abstracted) to create this work plan example.

A.1 INTRODUCTION

The U.S. Department of Energy (DOE) has contracted with a consultant to conduct an ecological assessment of the Washbone site near Burke County, Georgia. This ecological assessment is part of a focused remedial investigation/feasibility study (RI/FS) of specific areas at Washbone that DOE used to dispose of radioactively contaminated processing wastes. This work plan describes the ecological risk assessment designed to (1) identify the pathways of contaminant transport in terrestrial, wetland, and aquatic systems on and adjacent to the site; (2) identify biota potentially at risk from exposure to the contaminants; and (3) determine whether existing contaminants pose an unacceptable ecological threat. The results of the ecological risk assessment will (1) help determine if any remedial action is necessary, and (2) determine whether the site supports a valuable and viable biological community. Remedial options will be evaluated separately in the focused FS for the site.

A.1.1 Background and Site History

The Washbone site is located north of Waynesboro in Burke County, Georgia (Figure A.1). In 1991, the Washbone site was added to the National Priorities List (NPL) because of the extensive disposal of machinery and processing wastes contaminated with thorium and uranium at the site. In addition, chemical wastes (organic solvents) were incinerated in open pits.

Surveys conducted from 1986 to 1988 by DOE demonstrated that soil and groundwater contamination had occurred at the site. Since 1988, DOE has been conducting a hydrogeologic assessment at the site to characterize the distribution and movement of contaminants in soil, surface water, and groundwater. Since placement on the NPL, all on-site studies are being conducted under CERCLA. At present, DOE has initiated its studies as part of an RI/FS.

Because the Washbone site is on the NPL, any remedial activities conducted there are subject to the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and its 1986 amendments (the Superfund Amendments and Reauthorization Act, or SARA). CERCLA requires that lead agencies respond to uncontrolled releases or potential releases of hazardous substances; and that responses be protective of human health and the environment. Remedial actions must protect ecological resources and must be based on some form of ecological assessment. Additionally, a number of applicable or relevant and appropriate requirements (ARARs), such as the Endangered Species Act, Clean Water Act, and various state laws, could require additional standards, actions, or limitations at hazardous waste sites.

Two major contaminated areas occur at the site: a trench where wastes were burned and a landfill used for waste burial. In-depth surveys of the types and extent of contamination at these locations are provided in reports by DOE (1988, 1990).

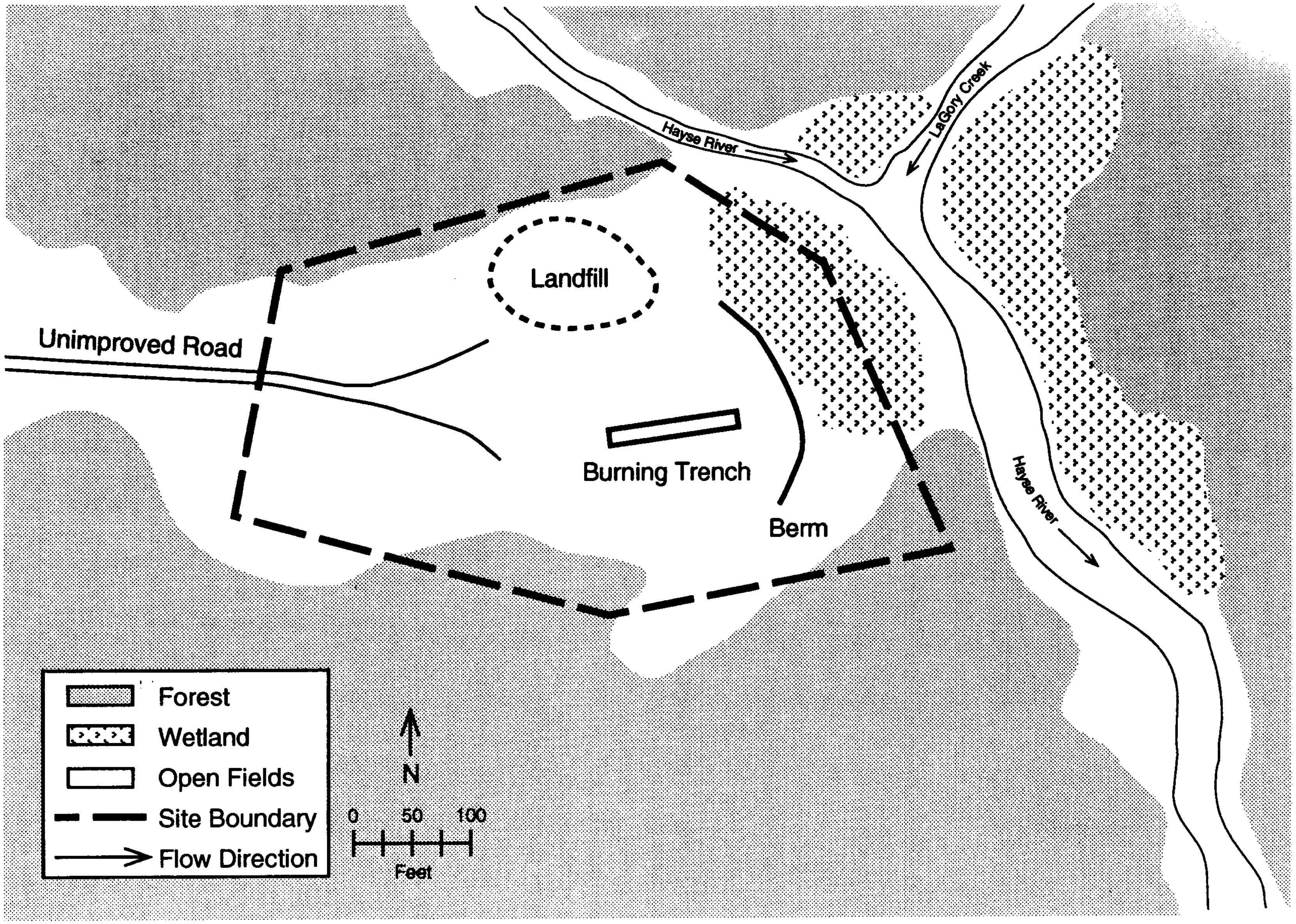

FIGURE A.1 Location of the Washbone Site

The trench area was used to dispose of drummed chemicals by burning. Some of the drummed chemicals (including chlorinated solvents such as trichloroethylene and polychlorinated biphenyls [PCBs]) are not highly flammable, and were probably incompletely burned. Thus, residues of some of the chemicals contaminated the soil, groundwater, and surface waters. A wetland adjacent to this pit could be contaminated by surface runoff and shallow groundwater movement. In addition, when this facility was being used, material from the pit was intentionally bulldozed into the wetland ("pushout area"). Preliminary data (DOE 1988) indicate elevated levels of metals and PCBs and other hydrocarbons in soils.

The landfill area was used to dispose of (by burial) empty or partially used containers, machinery, used spill containment materials, batteries, and other industrial waste materials. In addition to thorium and uranium, a variety of metals and organic contaminants occur within the landfill area at elevated concentrations (DOE 1990). Contaminant migration from the landfill may have affected nearby habitats.

A preliminary list of contaminants of concern for the site has been compiled in Table A.1 from data presented by DOE (1988, 1990). Detailed (quantitative) surveys of the biota that occur at the Washbone site and vicinity have not been conducted. Furthermore, no attempt has been made to assess the effects of contaminants on the biota within on- or off-site habitats.

A.1.2 Physical Setting

A.1.2.1 Climate

The Washbone site area has a modified continental climate characterized by moderately cold winters and warm summers. For the period 1975-1990, the monthly average temperatures vary from a high of 89°F in July to a low of 19.9°F in January. The prevailing winds in the area are from the south, with an average speed of 9.7 mph.

The normal annual precipitation is 33.9 in. Winter is the driest season, with an average precipitation of 6.3 in.; spring is the wettest season, with an average precipitation of 10.7 in. Snow occurs as early as October and as late as May, averaging 18.7 in./yr. Most snow falls from December through February. Thunderstorms are frequently associated with summer rains and are often accompanied by damaging rains. The frequency of thunderstorms recorded for the area is 37.4 d/yr.

Tornadoes may occur in the area once or twice per year, most often in April and May. Most have short and narrow paths and usually dissipate after a few miles. Only a limited number of tornadoes observed in the county have been associated with extensive damage or loss of life.

TABLE A.1 Contaminants of Potential Concern at the Washbone Site

Contaminant[a,b]	Site: Trench Area	Site: Landfill Area
Arsenic		X
Cadmium		X
Chlordane	X	
Chromium	X	X
Cyanide	X	
Lead		X
Mercury		X
PAH	X	X
PCB (Aroclor 1248)	X	X
Selenium		X
Silver	X	X
Sulfate	X	X
Trichloroethylene		X
VOC	X	X

[a] This list of contaminants is not inclusive.

[b] PAH = polycyclic aromatic hydrocarbon; PCB = polychlorinated biphenyl; VOC = volatile organic compound, including chlorobenzene, 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, vinyl chloride, trans-1,2-dichloroethylene, trichloroethylene, and tetrachloroethylene.

Sources: DOE (1988, 1990).

A.1.2.2 Geology and Soils

The Washbone site is located in low limestone hills near the west bank of the Hayse River. The mid-Ordovician bedrock of the area is predominantly limestone and dolomite. In the upland areas, the bedrock is overlain by 10 to 40 ft of unconsolidated materials consisting of alluvium, glacial drift, and weathered rock. Two distinct soil types occur in the area: loess deposits and residual soils that cover the upland regions and river alluvium found along the Hayse River and its tributaries.[2]

The principal surficial deposit on the upland surfaces is a silty clay soil developed from loess and deposited during and following the Wisconsin glaciation. A residual soil from weathering of limestone is present in some areas between the silty clay and bedrock.

Locally, the alluvium is composed of a surficial layer of 10 ft of silt underlain by about 20 ft of sand. The thickness of the silt layer increases toward the river. Beneath the sand, there is about 70 ft of sand and gravel. This water-bearing alluvium is a major contributor to the domestic water supplies of nearby towns.

A.1.2.3 Water Resources

A.1.2.3.1 Surface Water Hydrology. The Hayse River borders the eastern and northeastern edges of the site (Figure A.1). Most surface runoff from the site drains toward the east, although some surface runoff from the landfill area drains to the northeast. The northeastern portion of the site is largely an emergent wetland. The burning pit area at the site originally drained into the wetland. However, the berm created by the "pushout" has stopped surface water runoff from the pit area to the wetland.

A.1.2.3.2 Groundwater Hydrology. Groundwater in the vicinity of the site occurs in alluvium, fractured limestone and dolomite, and sandstone. Water-table conditions (unconfined aquifers) are typically found in areas of significant alluvial deposits; semiconfined conditions (confined to leaky aquifers) occur where layers of varying permeability are present. Flow in the limestone is primarily through secondary porosity provided by fractures and solution features. The St. Peter Sandstone, about 300 ft below the site, contains a confined groundwater aquifer. The degree of connection between this aquifer and the overlying formations is not fully understood.

Over most of the site, groundwater flows primarily from west to east. Surficial groundwater flows into the site wetland and the second order stream that borders the site

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[2] Discussions of the stratigraphic column, geologic cross sections, and other pertinent geologic information (with associated figures) should be included. They are omitted from this work plan example for brevity.

on the east. At the southern end of the site, the direction of groundwater flow is generally toward the south to the Hayse River.

Recharge to the bedrock in the vicinity of the site is limited to infiltration from precipitation or storm runoff. Discharge from the bedrock to the alluvium of the Hayse River floodplain may occur as springs, seeps, underflow, and flow to pumping wells. Recharge to the alluvial aquifer occurs primarily from the Hayse River and intermittent surface flooding, with minor amounts coming from infiltration and the underlying and adjacent bedrock.

A.1.3 Ecology

The site consists of open fields, second-growth deciduous forest (predominantly oaks, hickories, cottonwoods, and box elders), and wetlands (dominated by cattails); two streams border the east and northeastern portions of the site. A few areas of bare ground are located in the north central portion of the site, particularly in the vicinity of the disposal sites. Much of the land surrounding the site is state-owned wildlife area containing second-growth forest.

The biota at the site have not been surveyed in detail; however, common species are likely to include those typical to the surrounding wildlife areas. The Georgia Department of Conservation lists 23 amphibian, 42 reptile, 26 mammal, and 237 bird species for Burke County. Common mammal species include the eastern cottontail rabbit, opossum, raccoon, white-tailed deer, and several species of mice, voles, shrews, squirrels, bats, and foxes. Common reptile and amphibian species in the area include bullfrog, spring peeper, and a variety of salamanders, turtles, and snakes. About one-third of the bird species reported for the county nest in the area. Common birds in the area include a variety of warblers, sparrows, woodpeckers, red-tailed hawk, and American kestrel. Ten waterfowl species are common to abundant during the spring and fall migration, and a few species such as Canada geese, mallard, and wood duck nest or overwinter in the area.

The Georgia Department of Conservation lists over 100 species of fish for Burke County. On the basis of habitats and distributions of these species, the fish species that would most likely be abundant in the vicinity include gar, gizzard shad, carp, channel catfish, bluegill, largemouth bass, and a number of minnow and sucker species.

The Georgia Department of Conservation has identified 14 state endangered, 18 state rare species, and 13 other species as state watch list species or species of undetermined status for the county. Five of the state-listed species are also federal-listed as threatened or endangered, and another four are federal candidate (C2) species. However, no federally listed species, candidate species, or critical habitats have been identified by the U.S. Fish and Wildlife Service (FWS) as occurring at the site.[3]

Landsat^{TM} satellite data and digital photographic data have been combined to begin mapping of habitat types at the site and surrounding areas.[4] This habitat mapping will continue, with finer resolution applied to the site area. Throughout this work plan, all spatial data, including water, soil, sediment, and biotic sampling locations, will be entered in a geographic information system (GIS). The GIS will allow a one-to-one mapping of contamination and ecological receptors to clearly show receptors and habitat types at risk to chemical stressors.

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[3] This section should also contain a table that provides the common and scientific names of the species and their federal and state status. Additional text should also be provided on reported sightings of these species in the immediate site vicinity or habitats in or near the site that may be suitable habitats for any of these species. These have been omitted from this work plan example for brevity.

[4] A figure showing habitat types on and surrounding the site should be included. For brevity, this figure has not been included in this work plan example.

A.2 WORK PLAN RATIONALE

Three types of information are needed to establish a relationship between the occurrence of hazardous wastes and contamination at the site and any ecological effects (EPA 1989a):

1. Chemical analyses of the appropriate media are needed to establish the presence, areal and vertical distributions, and concentrations of the contaminants;

2. Ecological surveys are needed to determine if adverse effects have occurred; and

3. Toxicity tests are needed to identify potential ecological impacts and to establish a link between any realized adverse ecological effects and the toxicity of the hazardous wastes and contaminants.

Data for item 1 above will be collected primarily by other groups involved in the overall site focused RI. The ecology risk assessment team (and any subcontractors) will be responsible for items 2 and 3. However, successful completion of the risk assessment will require that all aspects of the effort (e.g., media sampling and biotic sampling) be fully integrated, both spatially and temporally (EPA 1989a).

Without these types of data, other potential causes of any observed ecological effects that are unrelated to the effects of the hazardous wastes and contaminants cannot be eliminated from consideration. For example, habitat disturbance or modification (e.g., conversion of forest habitat to a maintained grassy field) could have caused significant ecological effects, while contaminants may not be biologically available at concentrations that would result in any ecological impact.

The extensive movement of soil (from pushout activities) into the wetlands at the site has probably resulted in extensive sediment deposition in these wetland areas. Sediment deposited in an aquatic system changes the physical condition of the ecosystem and can dramatically alter the biotic composition in the affected area. This physical disturbance could easily confound the impacts caused by chemical contamination at the site. In addition, if much of the chemical contamination exists in groundwater that is not in contact with terrestrial or aquatic biota, impacts to ecological systems will not occur. Also, if the chemical contamination is sufficiently diluted as it is transported (especially in the groundwater) from source areas before it comes in contact with the biota, then ecological impacts could also be negligible.

Ecological effects of contaminants at the site will be estimated primarily at the population, community, and ecosystem levels of organization. Generally, ecological effects to individual organisms are only of concern if threatened or endangered species are involved (EPA 1989d). The FWS and the state of Georgia will be consulted before studies are begun of any listed species.

Use of a "weight-of-evidence approach that considers all bioassessment results" has been suggested to analyze the current and/or future risks to the biota at the site. Such an approach is best achieved by examining the hierarchical structure of populations, communities, and ecosystems. For example, laboratory population level effects can be easily measured with controlled toxicity tests and other manipulated laboratory designs (Levin and Kimball 1984). These tests generally provide a rigorous evaluation of chemical effects. However, toxicity tests are often extrapolated directly to expected effects on natural populations. Such extrapolations are rarely accurate because individuals vary in their sensitivity and because individual and population interactions (which could mask or magnify laboratory inferences) are not considered (Bartell et al. 1992). Thus, it is imperative that risk assessments be considered according to the ecosystem, taking full account of spatiotemporal variability in the physicochemical environment and how such variability might alter rates of ecological processes that determine population exposure to toxic compounds (Levin et al. 1989; Bartell et al. 1992).

In addition, remediation of hazardous waste sites necessarily involves the manipulation of community and ecosystem parameters that could incidentally affect these higher levels of organization. Thus, an ecological assessment must determine if these higher levels of organization have been affected by hazardous substances or physical disruption (NAS 1975; Levin and Kimball; Levin et al. 1989). In addition, measurements of community and ecosystem parameters can be accomplished in situ at the site and at reference locations, producing relatively direct measurements of differences among sites. If community or ecosystem structure does not differ between the site and a reference location; results from laboratory or other controlled toxicity tests would not provide sole justification to remediate on the basis of ecological considerations at the site.

At the community level, the main indicators of differences among sites include shifts in species dominance and diversity (including richness). Such shifts could be tied both to ecosystem functions (e.g., changes in density, biomass allocation, reproductive effort). Similarly, changes at the population level could be a direct result of contamination (e.g., species-specific toxicity) or an indirect result of changes in ecosystem or community processes (e.g., impacts to predators or prey). Because ecological sampling will be conducted at several locations over time, spatial and temporal variation in biotic and abiotic parameters can be detected. Evaluation of these variations will lead to a rigorous ecological risk assessment and result in a comprehensive appraisal of the importance of contaminants to ecosystem, community, and population factors at the site.

A.3 STUDY APPROACH AND DATA REQUIREMENTS

On the basis of preliminary data regarding site contaminant distribution and site biota and habitat distributions, a three-phased approach will be taken in further defining contaminant toxicity and exposure assessments. The rationale for this approach is based on an incomplete database regarding: the locations and areal extent of the contaminants, ecological receptors, and the potential for bioaccumulation or food chain transfer. First, contaminant concentrations from on-site and off-site media will be determined to identify areas that warrant the collection of additional field and chemical data. Essentially, Phase 1 will identify "hot spots" of radiological and chemical contamination. Phase 2 will include ecological surveys, toxicity screening, and chemical and radiological analyses at the hot spots identified in Phase 1. Phases 1 and 2 will be conducted as part of Stage 1 of the ecological risk assessment (Figure A.2). The results of Phase 2 will be used to identify those hot spots for which refined toxicity tests and in-depth ecological assessments will also be required. These refined toxicity tests and in-depth ecological assessments will constitute Phase 3. Phase 3 will be conducted as part of Stage 2 of the ecological risk assessment (Figure A.2). Given the nature of the contaminants and degree of contamination, reference areas will be selected and sampled as a basis for comparison with contaminated sites.[5]

The ecological risk assessment will be conducted in three stages (Figure A.2) to evaluate the effects of leaving the contaminated site in its present condition. Thus, Stage 1 will involve the initial determination of the current condition of a selected number of ecological parameters. The baseline condition of the site will be compared with ecological and physicochemical conditions at selected reference areas. Stage 1 of the ecological assessment essentially includes Phase 1 and 2 activities previously described. If the baseline condition is not different from that at the reference areas, or does not exceed ecological ARARs or other risk-based standards, the extensive analytical and toxicological tests that constitute Stage 2 of the ecological risk assessment may not be needed. The ecological assessment team then will recommend that extensive remediation is not warranted for the site based on ecological conditions. If ecological differences between the site area and selected reference background sites are noted and these differences can be reasonably attributed to chemical or radiological stressors rather than physical disturbance, or if ARARs or risk-based standards are exceeded, in-depth analysis will be completed in Stage 2 to determine the type of stressors and the current and future risk to ecological resources. Stage 2 essentially includes Phase 3 activities described initially in Section A.3.

Stage 1 work will be coordinated with the physical media (sediment, soil, and water) sampling being done to provide site characterization in support of the remedial investigation for the site. (Appendix B provides an annotated outline for an ecological field sampling plan.)

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[5] A brief mention of the reference site(s) should be included here.

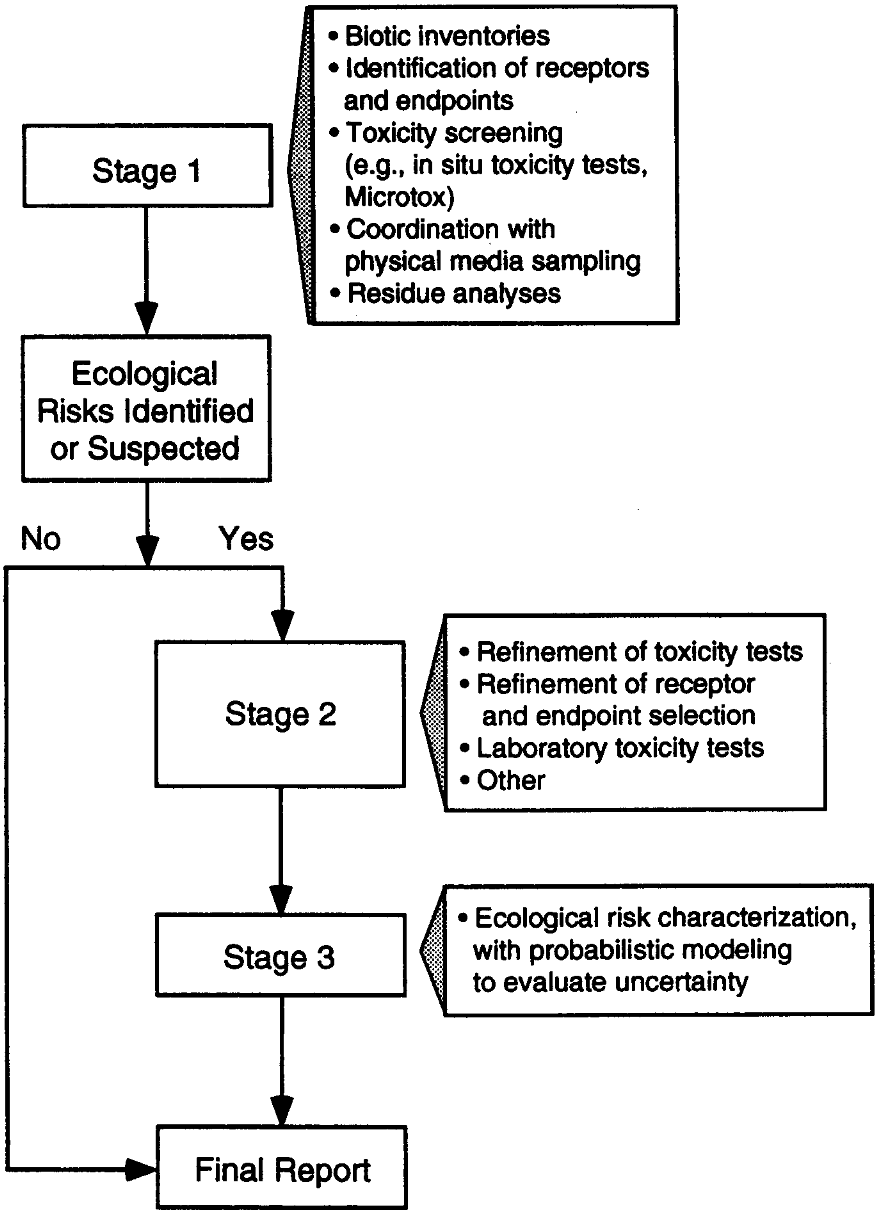

FIGURE A.2 Staged Approach Proposed for the Washbone Site Ecological Risk Assessment (Phases 1 and 2 of the field and laboratory investigations will be conducted during Stage 1; Phase 3 will be conducted during Stage 2.)

Stage 1 will also include surveys (i.e., sampling) of terrestrial, wetland, and aquatic biota. These surveys will be conducted for: (1) upland and wetland vegetation (herbaceous species, shrubs, and trees), (2) invertebrates (aquatic macroinvertebrates and soil invertebrates), (3) fish, (4) amphibians and reptiles, (5) birds, and (6) mammals. The field sampling plan describes survey methodologies. In some instances, sampling emphasis would be focused on a particular species or species group (e.g., insectivorous mammals) (see Section A.3.1 Receptors and Endpoints). These surveys will be compared with similar surveys at the selected reference sites. Media concentrations of hazardous substances at the site will also be compared with concentrations at reference sites, background areas, or other hazardous waste locations. Section A.4.1 discusses the methodologies to be used to obtain data for Stage 1, as well as how data will be compared between the Washbone Site and reference sites.

Stage 2 will be initiated if additional ecological surveys and toxicological assessments are needed. For this phase, more detailed data will be gathered for media and biota, both from the site and from the reference sites. Section A.4.2 provides more detailed information on activities and analyses to be conducted for Stage 2.

In Stage 3, field data and results from toxicological studies in Stages 1 and 2 will be used to characterize ecological risks at the site. Much of the determination will be based on comparisons or reference or background sites to the site. Differences found between reference samples and site samples do not necessarily indicate problems from contamination. To evaluate these potential differences, results from all the ecological surveys, toxicity tests, bioassays, and residue analyses will be used to determine ecological effects. EPA guidance will be used for the risk assessment and, specifically for the ecological assessment, the guidance directed at CERCLA cleanup actions will be used (EPA 1989a-c, 1991a).

A classic experimental design developed for statistical analyses requires random selection of control and experimental areas. Because the locations of contaminated areas at the site have already been determined by past activities, such an experimental design is not possible for the ecological assessment. Thus, many classic methods of hypothesis testing, such as analysis of variance, are severely restricted in use, interpretation, and inferences of causality (Stevens 1988). Because receptors located in a contaminated area and receptors located in the reference study area may not be from the same randomly chosen population of all receptors at or near the site, the key assumption about sampling a normally distributed group may be violated. Such a violation invalidates the statistical analysis of a "treatment effect" of chemical contamination on ecological processes. However, the hypothesis that the endpoints or measurements within the contaminated area are different than those found in the uncontaminated areas can be tested. Although differences do not imply causality, a set of differences can be used to infer that adverse effects are occurring in the environment.

The assessment process described in this work plan will provide:

- Baseline data on the status of the biota at the site,

- Estimates of the ecological effects of contaminants,

- Estimates of habitat alteration or modification from physical disturbances at the site,

- Identification of the extent to which effects have resulted specifically from radiological and chemical contaminants at the site.

To assist in formulating and refining the objectives of this ecological risk assessment, the ecological risk assessment team will consult with appropriate federal and state agencies concerned that site response actions address ecological concerns. These consultations will include the regional Biological Technical Assistance Group (BTAG), which consists of officials from the EPA and other agencies that are "natural resource trustees" under Superfund (e.g., U.S. Department of the Interior). The main functions of the BTAG are to (1) provide a forum for communication among agencies; (2) identify ecological concerns; (3) determine data needs; and (4) make recommendations, including suggested monitoring and assessment activities, sampling plans, analytical techniques, ecological endpoints, ecologically based ARARs, and beneficial and detrimental aspects of possible remedial actions (EPA 1989c).

A.3.1 Ecological Receptors

Because of the diversity of habitat types at the site (forest, old field, wetland, and stream), the complexity of an ecological risk assessment is readily apparent. One approach to developing such an assessment is to define a number of potential receptor species for each habitat type. Ecological receptors are biotic species selected as "indicators" to determine if contaminants are having a demonstrable effect on biotic communities. Species are selected as ecological receptors on the basis of their trophic level, habits, regulatory importance, and/or commercial and recreational importance. The selection of species as trophic-level indicators would depend on the contaminant of concern. For contaminants known to biomagnify (e.g., mercury), species at the top of the food chain (e.g., predators) would be likely candidates. However, for most metals and other contaminants that do not demonstrate biomagnification, plant species, herbivores, or detritivores would be selected as receptor species. An ecological receptor chosen for its habitat would be a species whose life history places it in direct contact with contaminants. Such species include those inhabiting and/or feeding within or upon sediments or soils (e.g., earthworms, amphipods, benthic insect larvae, tadpoles, bottom-feeding fish).

Species of regulatory importance include federal- and state-listed species. Under most situations, a surrogate species would need to be chosen for any field work conducted to determine ecological risks to a listed species. For example, a common minnow species with habitat requirements and/or prey base similar to a listed minnow species could be used for in-site caged toxicity tests.

Species of commercial or recreational importance are often chosen as ecological receptors because of their importance to man (e.g., economic and health concerns). Often, a species of recreational or commercial importance also has trophic or habitat characteristics that make it an ideal candidate as an ecological receptor (e.g., game fish and waterfowl).

Species generally appropriate as receptor species are listed in Table A.2. The final choice of receptors will be determined following initial ecological reconnaissance of the site to determine specific species from Table A.2 that are common to the site.

A.3.2 Systems Model and Pathway Analysis

The ecological assessment is an integral part of the ongoing and planned remedial activities at the site. As an aid in the integration of all activities, a systems model(s) will be developed to examine the connections between chemical fate and ecological effects.[6] The model(s) will show how the fate of contaminants is linked to the ecological receptors, assessment endpoints, and measurement endpoints. The systems model(s) will address environmental pathways (e.g., contaminated sediment and benthos) to simulate potential ecological risk. Modeling is particularly important for those species for which field sampling or toxicity testing cannot be done (e.g., threatened and endangered species).

The development of ecological models will be based on survey and inventory data and the information obtained from the statistical analyses of the field and experimental studies at the site. Those studies will determine parameter values for the models. In addition, the assessment team will rely on literature values for ecosystem parameters, especially for toxicity values, bioaccumulation factors, and physical parameters (e.g., soil and sediment properties). The field studies will assist in determining the variation, or range of values, for parameters and variables in the models. By acquiring information on the range of conditions found at the site, we can explicitly incorporate the variance of the ecological conditions. This variance is a normal property of ecological systems and could have a major effect on decision making for remedial actions.

A.3.3 Published Standard Methods and Protocols

Methods and protocols (including field sampling methods, material handling, laboratory assays, and data analyses) used in all tasks associated with the ecological risk assessment will follow published standard methods or guidelines where practicable and appropriate. Standard approaches for toxicity testing include those proposed by the American Society for Testing and Materials (ASTM 1992) and discussed in Section A.4.1.4. Unlike the case for human health risk assessments, ecological risk assessment methods have not been standardized. The selection of appropriate methods and assumptions is a matter of much

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[6] The choice of applicable systems models to use needs to be determined on a site-by-site basis; depending upon site features, contaminants, contaminated media and habitats, and biota. The U.S. Environmental Protection Agency, Office of Health and Environmental Assessment (OHEA), Exposure Assessment Group, Washington, D.C., has sponsored the development of EML/IMES (Exposure Models Library with the Integrated Model Evaluation System). EML/IMES contains over 60 models which may be used for exposure assessments and fate/transport modeling. Further information on EML/IMES can be obtained from the OHEA by calling 202-260-8922.

TABLE A.2 Potential Ecological Receptor Groups for the Washbone Site Ecological Risk Assessment

Species (or group)	Rationale	Assessment and/or Measurement Endpoints
Terrestrial plants		
Woody species	Long-term indicator	Percent cover
Herbaceous species	Short-term indicator	Production Percent cover
Aquatic plants		
Duckweed[a]	Short-term indicator	Production
Cattail	Dominant species	Production
Terrestrial invertebrates		
Earthworms[a]	Direct contact with soil	Population size Distribution
Small mammals		
Local indicator	Short-term indicator	Population size Diversity
Birds		
Predatory	Ecological "integrators"	Population size
Aquatic	Integrators	Population size
Amphibians[a]	Short-term indicator	Diversity Population size Development
Fish[a]	Commercial and recreational importance	Diversity Age-structure
Invertebrates		
Benthic insects[a]	Short-term indicator, sediment contact	Diversity Population size

[a] Representative species from these groups are also utilized in laboratory and field toxicity tests.

debate. Nonetheless, some generalities can be drawn, especially with respect to choice of receptor species and endpoint determinations. The ecological field sampling plan and quality assurance project plan (QAPP) provide further details on standard methods and procedures. (Appendixes B and C provide annotated outlines for an ecological field sampling plan and a QAPP, respectively). Guidance will also be drawn from other relevant sources, including the EPA (1989a-d, 1991a)

All tasks undertaken by subcontractors will also follow accepted and standard methods. Additional information on chain-of-custody procedures and quality assurance/ quality control (QA/QC) are provided in the QAPP.

A.3.4 Literature Search of Toxic Effects of Known Contaminants at the Site

Field data, monitoring information, and toxicity-testing results of contaminated media generally are more beneficial and reliable than estimates made from literature reviews (EPA 1989c). However, published studies can be useful in deciding (1) types of toxicity tests (e.g., acute or chronic) to be conducted with field-collected samples, (2) kinds of organisms to be tested, (3) effects to be expected, and (4) how toxicity tests should be interpreted (EPA 1989c). Information will be gathered from the literature on the relative toxicity of elements or compounds to various biota (e.g., mammals, fish, invertebrates, or plants) and on contaminant fate in the environment. Also, an in-depth review of the literature will help restrict the screening of organisms to those few species that might be good indicators of habitat modifications. This literature review could lead to use of procedures that would be economical of time and funds (EPA 1991b). A search of the literature could also be beneficial in the identification of data gaps regarding the effects of a particular contaminant to biota.

A.4 SCOPE OF PROPOSED TASKS

Tasks for each planned stage are defined in the following subsections. The study scope may change on the basis of preliminary results from field and laboratory testing obtained in the tasks for each phase.

A.4.1 Stage 1 Task Descriptions

The tasks described below include field assessments, toxicity assessments, and ecosystem modeling to evaluate potential ecological risks at the site. These approaches should be considered to be complementary rather than separate assessment methodologies.

A.4.1.1 Identification of Site Sampling Locations

The sampling program for the ecological risk assessment will be coordinated with the physical characterization being conducted as part of the overall RI effort at the site (BPV 1992). This will be necessary to minimize statistical variability in the analytical results associated with site differences at the site and with temporal changes in chemical concentration, fate, or toxicity.

Previous media sampling of groundwater, surface water, and soil conducted by DOE (1988, 1990) in the site area provides a preliminary determination of the spatial extent of chemical contamination. However, the transport and fate of the contaminants at each potentially contaminated area have not been documented. The incompleteness of the data suggests that ecological sampling should focus on areas in and around the contaminated areas and in terrestrial, wetland, and aquatic ecosystems.

Figure A.3 shows the areas proposed for ecological sampling. The areas include up- and downgradient locations from each disposal area at the site. Within these locations, samples of environmental media and biota will be collected concurrently to ensure statistically and ecologically valid comparisons of the sampling results. The ecological field sampling plan (BPV 1993a) provides detailed information on the location and number of physical media samples. The ecological assessment will use these locations to ensure that biological samples match media sampling. In addition, all in-situ analyses will be conducted at these locations. A grid will be positioned at each area, and a subset of locations within the grid will be randomly chosen for sample collection. An appropriate number of collections will be chosen to ensure that standard errors will be minimally affected by sample size, thus reducing statistical uncertainty. In addition, the appropriate number of random locations will permit use of simpler, more straightforward test statistics than would be possible with a smaller sample size.

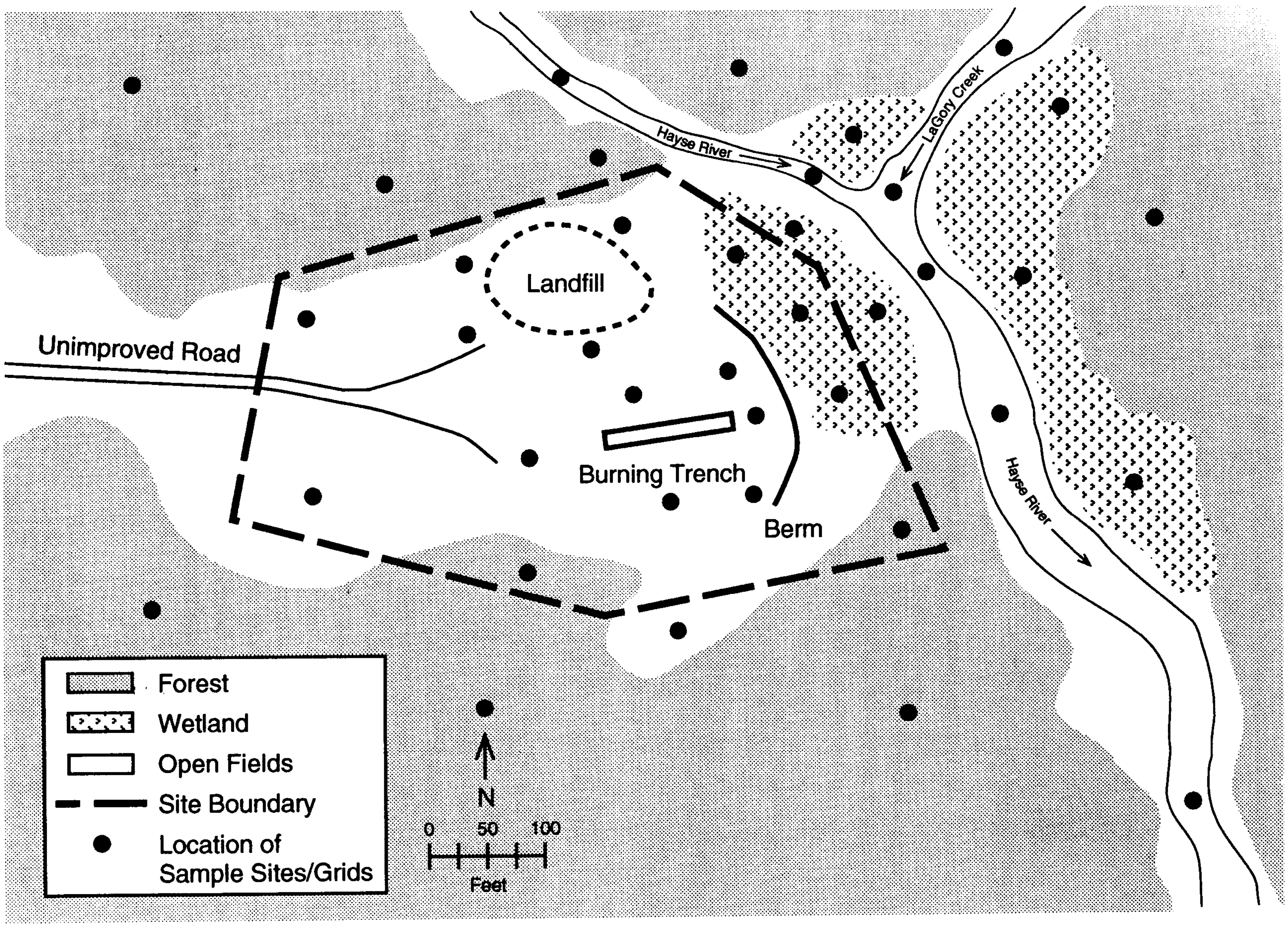

FIGURE A.3 Proposed Ecological Sampling Locations at the Washbone Site

Because of the physical disturbance in the pit areas (e.g., excavation and vehicle disturbance), the up- and downgradient locations must be situated so that the spatial heterogeneity of the disturbed areas does not interfere with or confound the sampling results. For example, bare areas around the disposal areas must be compared with other bare areas, and downgradient forested or wetland habitats must be compared with similar upgradient or reference site habitats. Most of the field sampling program will be directed at thorough investigations of the extent of contamination and effects to wetland, stream, and late successional terrestrial communities. The final locations selected for ecological field sampling will depend on media sampling work to delineate the locations of the disposal area contaminants.

A.4.1.2 Reference Site Selection

Essential to interpretation of endpoints or measurements in a sampling program is the selection of appropriate reference sites (Stevens 1988; Hunsaker et al. 1989; Orvos and Cairns 1991). For this assessment, reference sites will be uncontaminated locations that have habitat and hydrologic characteristics similar to those in potentially contaminated areas of the site. To test for differences between sites due to contaminants, contaminated and reference locations must have similar properties, including topographic conditions, landscape shape and size, soil and sediment properties, habitat type, and habitat disturbance.[7]

A.4.1.3 Field Sampling

Field sampling of flora, fauna, soils, sediments, and surface waters will be conducted at on-site locations (including bordering streams) and reference locations. Sampling protocol is discussed in Section A.6. On-site and reference locations will be matched as closely as possible in terms of all relevant ecological factors to permit appropriate comparisons. On-site areas sampled at the site will include forest, old-field habitat, bare/sparsely vegetated areas, marsh, and stream habitats.

Initial biotic surveys and sampling at these locations will be used in part to identify appropriate ecological receptors. For Phase 1, all on-site samples will be collocated with samples of soil, sediment, and water (BPV 1992). Sampling sites at reference locations will be selected on the basis of similarity of habitats and hydrology to the site locations.

The field sampling approach has been designed to evaluate in situ comparisons between the site and the reference locations. These comparisons will form the background under which controlled testing and analysis will be judged within the ecological risk assessment. Specific toxicity tests, residue analyses, microcosm analyses, or field experimentation (e.g., caged studies) described in other sections of this document are used to focus attention on explicit ecological factors (i.e., test organisms) or areas of contamination.

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[7] A discussion (and accompanying figure, if appropriate) would be included on the reference sites. For brevity, it is not included here.

These explicit tests will be used to make the connection between a specific chemical(s) and a narrowly defined ecological response. Thus, use of toxicity tests, residue analyses, or other controlled studies will reduce potential uncertainties in the field sampling and analysis.

A.4.1.3.1 Population Parameters. The major population parameters to be estimated include species density(number of individuals per unit area), plant cover(areal coverage for a species within a unit area of habitat), and plant biomass (plant weight per unit area). Readily detectable differences in individual size classes between receptor populations at the site and the reference sites could suggest some important abiotic ecosystem differences among or within those sites. These data will permit comparison of species performance among sites.

A.4.1.3.2 Community Parameters. Three important community parameters, readily measured from field sampling, are (1) species dominance (or relative rank of species on the basis of numbers or biomass), (2) diversity(consideration of both the number of species and the distribution of individuals among the species), and (3) community similarity (comparison of both the similarity in composition and the similarity in number of individuals per species between sites). Shifts in species dominance and diversity have long been used as indicators of pollution or other anthropogenic disturbance.

A.4.1.3.3 Ecosystem Parameters. Ecosystem field studies are conducted to detect effects that might be undetected in population or community studies or in simplified systems (NAS 1975; Kimball and Levin 1985). As alluded to above, impacts observed at one ecological level (e.g., population) do not translate readily into effects at another level (e.g., ecosystem) (Kimball and Levin 1985). Furthermore, chemicals that appear to be safe in single-species toxicity tests can be transformed under field conditions and cause toxic effects (Kimball and Levin 1985).

An important ecosystem measure for hazardous waste sites is actual or potential biomagnification of hazardous substances. To evaluate magnification, analyses will be conducted to determine if site contaminants move through the food chain or if uptake in vegetation represents a significant ecological problem at the site.

A.4.1.4 Preliminary Toxicity Tests

During Phase 1 of Stage 1 (Figure A.2), preliminary screening assessments of media toxicity will be conducted at the site for terrestrial and aquatic organisms. The media to be tested will be collected from sites known to be contaminated. Toxicity tests on soils, sediments, and water will be used to (1) determine the relationship between toxicity and media concentrations, (2) investigate interactions among contaminants, (3) determine spatial and temporal distribution in contamination, (4) rank areas for remedial action, (5) estimate the effectiveness of management and remedial options, and (6) identify areas of contamination for further investigation (Ingersoll 1991). Furthermore, such tests can supplement chemical residue data in determining remedial actions and may be more sensitive to low levels of contamination than other monitoring methods. Also, these media tests can indicate toxicity of mixtures of contaminants more readily than can single-chemical criteria (EPA 1989a). Because not all species are equally sensitive to contaminants, a number of toxicity tests[8] involving individual species from different trophic levels would be required to fully assess soil, sediment, and water quality (Ingersoll 1991). Ecological surveys will also be used to assess effects; therefore, multispecies tests should not be necessary to test for higher level ecological effects. Several sensitive single-species tests are often adequate to identify sources and probable causes of toxicity at hazardous waste sites (EPA 1989d).

A.4.1.4.1 Terrestrial. Several tests are available for rapid assessment of soil toxicity. The most widely used terrestrial target organisms are earthworms and plant seedlings (Karnak and Hamelink 1982; Wang 1986a; Wang et al. 1990; Callahan et al. 1991; Carlson et al. 1991; Gorsuch et al. 1991). Earthworms and seedlings (e.g., lettuce, radish, and/or sedge) will be grown in soil samples collected from random locations within grids established at the site and reference locations. An additional set of controls will be grown in laboratory control soil. In-field bioassay tests of earthworms will be conducted at upland locations (e.g., up- and downgradient of the disposal sites) to determine the spatial pattern of potential soil toxicity (Menzie et al. 1992). Appropriate Microtox toxicity tests will also be conducted at these locations (see Section A.3.1.2 for further detail).

Assessment of invertebrates (e.g., species diversity and other community parameters) within the soil below the litter layer is another initial screening method that will be used to infer or indicate the potential for upland soil contamination at concentrations that may be toxic to biota (Menzie et al. 1992). This assessment will be conducted at upland grid locations. Small wooden boards will be placed on the ground; after several days, they will be overturned and invertebrates under the boards will be collected, identified, and counted. This method is rapid and inexpensive.

Other studies have used captured animals from contaminated and uncontaminated areas to assess toxicity by comparing tissue levels of contaminants and survivorship curves (e.g., Rowley et al. 1983). Whole-body and tissue contaminant (residue) analyses will be initiated after media analyses indicate potential contaminants and locations of concern vis-a-vis bioaccumulation. Therefore, these residue analyses will be performed late in Phase 1.

Massive mortality or the absence of expected species from a community can suggest the occurrence of lethal levels of exposure to a contaminant. However, tissue or whole-body analyses (plant or animal) can identify sublethal and chronic, low-level exposure to a source of pollution (EPA 1991). In conjunction with soil, sediment, and water analyses, determination of contaminants in biota would permit a determination of bioconcentration,

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[8] The procedures for conducting the toxicity tests would be fully detailed in the QAPP (as appendixes to that document). An annotated QAPP outline is included as Appendix C.

bioaccumulation, and biomagnification potential of the contaminants of concern within the site. Generally, soil- or sediment-inhabiting organisms have higher tissue concentrations of contaminants (particularly metals) than other organisms. However, some contaminants (particularly those that are lipophilic, such as mercury and organic materials) tend to biomagnify. Therefore, species at higher trophic levels tend to display greater concentrations of such contaminants. Certain species from various habitats or trophic levels would be selected (on the basis of the preliminary literature review) to assess contaminant levels in biota. Biotic contaminant analyses would involve organs or tissues in which contaminants of concern are known to accumulate (for sublethal or chronic assessments) and whole body concentrations (for trophic analysis assessments).

Species selected for toxicity tests could also be used for in situ bioconcentration analyses. Aquatic macrophytes, macroinvertebrates, amphibians, bird eggs or young, and small mammals are preferable organisms for assessment of short-term exposures to contaminants; whereas, fish, reptiles, woody plants, large adult birds, and furbearers or large game mammals may be more suitable for monitoring long-term exposures (Leibowitz and Squires 1991).

A.4.1.4.2 Wetlands and Streams. Tests intended to provide a preliminary indication of the toxicity of site media to aquatic biota will analyze sediments and interstitial and overlying (open) waters. Sediment-dwelling biota can be exposed to contaminants from all three of these media. Additionally, feeding habits can influence the contaminant dose. For many benthic invertebrates, the toxicity and bioaccumulation of sediment-associated contaminants such as metals and nonionic organic materials have been correlated with the concentration of these contaminants in interstitial waters rather than with sediment-bound concentrations.

As feasible, guides and practices for sediment and water toxicity testing accepted by the ASTM (e.g., 1992) will be followed. These guidelines and practices include choices of biotic species for testing and sample collection, handling, and testing procedures. Other supplemental tests and species appropriate to physical, chemical, and biological conditions at the site would also be considered. Appropriate agencies (e.g., the EPA) would be consulted before such tests were undertaken.

The following paragraphs discuss various test methods and/or biotic species suitable for preliminary toxicity testing of wetland and stream sediments and waters. Methods to assess the toxicity of freshwater sediments are discussed by Burton (1991).

Amphipods are appropriate species for sediment toxicity testing because they are ecologically important, have a wide geographic distribution, are easy to handle in the laboratory, and are highly sensitive to contaminated sediments (ASTM 1990b). Test results will be based on mortality and sublethal effects, such as emergence from sediment and inability to bury in clean sediment following exposure to test sediment.

The Microtox Toxicity Test System™ and associated Microtox Solid-Phase Test™ will be used to detect and measure the toxicity of water and sediments, respectively. Although not definitive, the Microtox test systems can provide initial screening of media toxicity within a relatively short time. When used in conjunction with other toxicity screening tests during Stage 1, the Microtox test systems should provide results indicating which media and sites require refined toxicity testing during Stage 2 and results permitting initial comparisons among sites.

A phytoplankton assay (algal growth bioassay) will be conducted using *Selanastrum capricornutum.* This test is one of the few recognized methods for testing toxicity to aquatic primary producers. This test compares both biomass and chlorophyll *a* content as measures of algal growth. In addition to tests using freshwater algae, growth of *Lemna* sp. (duckweed) or other free-floating plant species also will be used to monitor tissue uptake from water and to conduct chronic toxicity tests. Use of only an algal species or a vascular plant species is not as sensitive for screening contaminants as is use of both plant types (Fletcher 1990). Unlike rooted vascular plants, which have been shown to have unsatisfactory correlations for biomonitoring of sediment-bound metals (Outridge and Noller 1991), free-floating vascular plants have been shown to be reliable indicators of water pollution. Culture and experimental conditions will follow published methodologies (e.g., Wang 1986b; Fletcher 1990; Cowgill et al. 1991). Testing endpoints would include reduction in number of plants, fronds, or dry weight.

In situ (caged) toxicity tests will be conducted with fish, tadpoles, crustaceans (e.g., crayfish), clams, snails, rooted or floating vascular plants, or other species that can readily be maintained in a partially enclosed test chamber under field conditions. Endpoints will include such parameters as growth, survival, deformities, and contaminant uptake. Final selection for in situ caged studies will be determined following initial ecological reconnaissance of the site and the reference sites. To avoid introducing species not presently established (i.e., exotics) in the area, only species indigenous to the sites would be used. (Note: If excess mortality at control sites is observed [usually >10%], the results of in situ test results should be used with caution, if at all.)

In summary, a battery of screening evaluation bioassays will be used to determine if sediment and water at the site are toxic to terrestrial, wetland, and stream biota. Toxicity tests used will be simple, reproducible, inexpensive, ecologically relevant, and relevant to regulatory criteria (Giesy and Hoke 1989). From the discussion above, it is evident that several test organisms and techniques are suitable for toxicity testing of soil, sediment, and water. A final selection or refinement of proposed tests will be made on the basis of discussions with various federal agencies (e.g., member agencies of the regional BTAG), results of biotic surveys at the site, and published papers.

A.4.1.5 Summary of Stage 1 Approach and the Need for Further Investigation

In summary, Stage 1 of this ecological risk assessment will concentrate on several activities: (1) quantitative inventory of the biota from the different habitats and/or ecosystems at the site and selected reference areas; (2) identification of potential receptor species; (3) identification of appropriate assessment and measurement endpoints; (4) performance of in situ and, if feasible, laboratory toxicity tests of soil, sediment, and surface water; (5) residue/tissue analysis; and (6) construction of a systems model for the site.

The completion of Stage 1 will determine how Stage 2 will proceed (if Stage 2 is necessary) and provide information necessary to complete the risk characterization in Stage 3. The results from Stage 1 should clearly demonstrate that the site ecological endpoints or parameters are currently affected or could be affected by past chemical or radiological disposal and thus determine the need for additional characterization or remediation. To evaluate this need the following five general result topics will be considered:

1. *A statistical comparison of the site area and selected reference areas.* The statistical analysis should show a difference in several of the field parameters discussed in Section A.4.1.3. However, results of the field studies will be presented to all concerned parties. Ambiguous or conflicting findings could lead to Stage 2 studies, if recommended by the assessment team or required by DOE or the EPA.

2. *Toxicity tests of chemicals and contaminated media.* If such tests clearly show (based on statistical significance) that the site contamination poses a risk to test biota, Stage 2 studies will proceed. (In addition to the toxicity tests, the literature search will be used to evaluate chemical toxicity.) However, the fate studies conducted at the site must also show that the test conditions mimic projected conditions. For example, current chemical contamination could be attenuated or unavailable to the biota over time under current transport and fate conditions.

3. *Residue analyses demonstrating bioaccumulation of biologically hazardous chemicals at the site.* The fact that bioaccumulation is noted will not necessarily result in Stage 2 studies. The residue analysis must show that (1) the biouptake of the chemical or metal is producing or could produce deleterious results in biota; (2) bioaccumulation is widespread at the site; and (3) bioaccumulation poses a threat to human health, top predators, or threatened and endangered species.

4. *Transport and fate studies of chemical contamination at the site.* Because such studies have not been initiated, results will be factored into the requirements for Stage 2 studies. For example, if contaminated groundwater or sediment is found, projected to be widespread, or biologically available, Stage 2 studies will be initiated. The site

ecological assessment team will work closely with others at the site to guarantee that the transport and fate studies are considered in the ecological assessment.

5. *Discovery of protected species (e.g., federally threatened or endangered) during the inventories at the site.* Such a discovery may require specific consideration of these populations in Stage 2. Any work on protected species will be coordinated with the FWS, DOE, and the EPA.

As part of the decision process at the end of Stage 1, results will be presented to DOE staff, other contractors, and the EPA to reach a consensus on the need for further investigations under Stage 2. Thus, the completion of Stage 1 could result in modifications to the present work plan. The ecological assessment team will also communicate with colleagues at the BTAG and other contractors working at the site throughout Stage 1.

A.4.2 Stage 2 Task Descriptions

If the Stage 1 activities indicate some degree of ecological risk from on-site contaminants, the ecological assessment effort will be continued and expanded as Stage 2. The decision to initiate Stage 2 will depend upon the results from Stage 1, evaluation of the five Stage 1 topics (Section A.4.1.5), and professional judgment. Results from the preliminary toxicity tests and from the chemical characterization of the site will be used to refine toxicity tests, as necessary. For instance, specific chemicals identified from the disposal sites may be targeted, additional sites may be considered, or some sites may be eliminated from consideration. If Stage 2 is initiated, attention will likely focus on specific areas of contamination. Where feasible, toxicity tests conducted during Stage 2 would make use of species that inhabit the site. Furthermore, assessment and measurement endpoints and ecological models may require refinement. Results from Stage 2 will be translated into remediation goals and objectives in the ecological risk assessment report.

Selection and initiation of Stage 2 activities will depend in part on the evaluation of certain post-Stage 1 "decision points." For example, if statistical comparisons of field samples from the site and a reference location suggest significant differences (rejection of the relevant null hypothesis), appropriate Stage 2 activities will be initiated. These activities would include tissue analyses of biota common to both sites and further characterization of the sites' physical characteristics, with the Stage 2 objective being to determine if stress, mortality, or other measure of performance is a result of contamination or physical site disturbance.

As a further example, Microtox and preliminary bioassays (Stage 1) could provide evidence of toxicity or bioaccumulation. If this decision point is obtained, laboratory toxicity tests, histological studies, and establishment of microcosms would be established in Stage 2. Detection of residues in tissues (Stage 1) at a level considered to indicate the potential for toxic effects or bioaccumulation (decision point) would initiate further laboratory toxicity testing in Stage 2.

Likewise, widespread, locally high, or temporally variable contamination will be verified in Stage 1 to justify additional field studies. Studies of caged populations of aquatic organisms will be included. For instance, caged studies could be performed at points where contaminated groundwater discharges into wetlands or streams. Finally, discovery of some sensitive ecological condition, species, or habitat during Stage 1 will be used to justify initiation of further Stage 2 characterization efforts, including refinement of receptor and endpoint selection.

Clearly, several Stage 1 activities could lead to the same Stage 2 efforts (e.g., toxicity tests and residue analyses) but at a finer level of resolution or at a different location at the site.

A.4.3 Stage 3 Determination of Ecological Risk

The EPA has produced guidance for the types of information that could be included in the risk assessment (EPA 1992). These guidelines will be used for the risk assessment. The following information is included in the EPA guidelines:

- Observed adverse effects in potentially exposed habitats compared to reference sites;
  - Mortality and morbidity;
  - Vegetation stress;
  - Habitat degradation;
  - Presence or absence of key species;
  - Population assessment of key species;
  - Community indices;
  - Ecosystem functions, such as decomposition or nutrient recycling;
- Analysis of contaminant concentrations in relation to observed adverse effects;
- Analysis of bioaccumulation studies;
- Analysis of toxicity test results in relation to observed adverse effects;
- Comparison of estimated exposure point concentrations with criteria and standards;
- Comparison of estimated exposure point concentrations with toxicity data and/or toxicity values from literature, as appropriate;

- Likely ecological risks associated with present and future land use scenarios;
- Ecologically applicable or relevant and appropriate requirements (ARARs);
- Ecological considerations in selecting remedial alternatives (including no action); and
- Uncertainty analysis.

The results from Stages 1 and 2 will be used to provide the decision maker with information on (1) the need for remedial action at the Washbone site on the basis of ecological criteria and (2) (if remedial action is required) the type of remedial action that will protect the resources analyzed in the assessment. In the risk analysis, findings from field studies and toxicological analyses will be combined with the ecological models to develop a set of remedial action objectives and remediation goals. The risk assessment will also include an analysis of the impacts of any proposed remedial action on the ecological systems at the site.

A.5 REPORT PREPARATION

At the conclusion of Stage 3, a report will be prepared detailing the findings of the risk assessment and the projections of the system models. That report will document the areas sampled (terrestrial, wetland, stream), the biota sampled, the toxicity test results, the model assumptions and parameters, and all other necessary and relevant data contributing to the final ecological risk assessment for the site. The final report format will follow that proposed by the EPA (1992).

A.6 SAMPLING PROTOCOL

A.6.1 Sampling Strategy

Much of the field sampling and data collection methods will follow those outlined in the ecological field sampling plan (BPV 1993a). Appendix B provides an annotated outline of this plan. The following sections reiterate the more salient points regarding field sampling and data collection and provide additional considerations for conditions that might be unique to the site.

A.6.1.1 Wetland Sampling

Analyses of the wetlands at the site and reference site will include interpretation of aerial photography and ground-truthing. These data can provide information on wetland vegetation community composition; wetland edge and open-water patterns (e.g., seasonal and long-term); occurrence and aerial coverage of terrestrial vegetation; occurrence and extent of sediment plumes; occurrence and intensity of algal blooms; and occurrence and number of muskrat dens, waterfowl nests, or other indicators of wildlife activity. All aerial photography will be placed in a digital database and manipulated with a GIS.

Jurisdictional wetland delineation (Federal Interagency Committee for Wetland Delineation 1989) and characterization (Cowardin et al. 1979) will be conducted to provide a detailed mapping of the wetlands within the site and the selected reference sites. The wetland maps will be used to formulate sampling strategies and will be placed in the site GIS database. The maps will also be useful for GIS analyses of contaminant concentration contours, surface and groundwater flow patterns, areas of physical disturbance, and other factors. The GIS data will provide an initial analysis of wetland areas of potential ecological concern relative to contaminant migration.

Field sampling will be conducted within the wetlands to determine community composition and abundance of vegetation, vertebrates, and macroinvertebrates. At a minimum, surveys will be conducted during two seasons (spring and late summer/early fall) to determine temporal conditions.

Data to be obtained from field sampling of wetland plant communities will include species composition and density, species dominance, percent vegetation cover, vegetation height, horizontal homogeneity or patchiness, percent occurrence of exotic and native species and obligate and facultative wetland species, and occurrence of species considered tolerant or intolerant of anthropogenic stressors.

Macrophyte surveys will coincide with the period of maximum growth (i.e., early summer). Methods used to inventory wetland vegetation include point-counts, quadrats, or other established plant sampling techniques.

Vegetation surveys will consist primarily of visual observations. Voucher specimens and those specimens not readily identifiable in the field will be collected with standard plant sampling techniques. Collected specimens will be placed in individual plastic bags with labels identifying the collector, date, collection location, and taxonomic identification, if known. All collected voucher specimens will be processed with standard plant collection and preservation techniques and maintained in the site herbarium collection. Some specimens will be used for tissue analyses and for estimates of biomass/standing crop.

Sampling within wetlands will be conducted for fish and amphibians to provide estimates of species density, distributions, and diversity. Techniques for sampling fish will vary with habitat type and species expected (if any) but could include the use of electroshockers, seines, minnow traps, or lift or drop nets. Areas of importance to herpetofauna life cycles (e.g., breeding concentration areas) will be determined, and surveys will be conducted at least twice (spring and summer) during periods of greatest herpetofauna activity. Drift fences with pitfall traps or funnel traps will be used to collect herpetofauna. Timed searches (e.g., walking transects, overturning logs, searching slash piles, dip netting within standing water) will also be conducted to collect herpetofauna.

A variety of methods (e.g., sediment corers, dredges or grab samplers, sweep and dip nets, emergence traps) will be used to collect macroinvertebrates. Methods used will depend on the habitats and habits (e.g., sediment, open water, epiphytic) of the macroinvertebrates. Macroinvertebrate surveys will be designed to provide estimates of species density, distribution, and diversity.

A census survey (using timed searches) will be conducted in the wetland areas for waterfowl and shorebird use. Identification will be made by species; and the location, sex (for adults), and activity of each individual will be recorded. The summer census will attempt to determine if individuals use the on-site wetland for extended periods of time. Waterfowl and shorebirds using this habitat would have the potential for contaminant uptake from sediments and water. Depending upon the results of the survey, waterfowl game species may be collected for contaminant residue analyses.

Selected species of vertebrates and macroinvertebrates will be assessed for indications of contaminant effects, such as spinal deformities, fin erosion, and head capsule deformities.

Observational data on wetland condition can also provide potentially useful indications of wetland stress (EPA 1991b). Observational field data could include notation of debris accumulations, canopy dieback, presence of an unusual amount of fallen limbs, and damaged (including fire damaged) and uprooted trees.

A.6.1.2 Stream Sampling

The primary contaminant migration pathways to the streams bordering the site would be groundwater discharge and surface runoff. Bank erosion could result in contaminated soil entering the streams. Field sampling will be conducted at select locations at, upstream, and downstream of the site to determine community composition and abundance of fish and macroinvertebrates. Surveys will be conducted at least twice (spring and late summer/early fall) to determine seasonal and/or high and low discharge differences to the biota. Fish will be sampled primarily with seines and/or by electroshocking. Macroinvertebrates will be collected with quantitative sampling devices appropriate to the substrate conditions (e.g., Hess or Surber samplers for cobble substrates or corers or grab samplers for soft bottom substrates).

A.6.1.3 Terrestrial Sampling

Quantitative sampling of terrestrial flora will follow commonly accepted methods (e.g., Mueller-Dombois and Ellenberg 1974; Barbour et al. 1987). Sample plots will be larger for woody vegetation (e.g., 10 × 10 m) than for herbaceous vegetation (1 × 1 m). Nested plots will be used where both woody and herbaceous vegetation occur. For woody vegetation, species and diameter at breast height will be recorded for each specimen in each woody vegetation plot. In addition, total canopy cover (percentage) will be recorded. For herbaceous samples, species, percent cover, and density will be recorded. These data will be used in estimates of population and community parameters.

Mammals will be sampled by EPA Class 1 techniques (EPA 1989c), including use of both live and snap traps. Live animals will be identified, tagged, weighted, sexed (if possible), and released. The same data will be recorded for dead animals. In addition, tissues or organs from dead animals will be analyzed for contaminant levels. Soil and litter invertebrates will be sampled with established collection methods to allow quantitative comparisons among sites. Those surveys will provide estimates of species density, distribution, and diversity. These data, together with the data from the vegetation sampling, will be input directly into the ecological risk assessment models.

Bird surveys will be conducted during spring and autumn migrations, breeding seasons, and the annual nationwide Christmas bird count. Surveys will be conducted using timed observational census methods. Binoculars, spotting scopes, and vocalizations will be used to document species occurrence. At each location, observations will be made for 15 minutes. Data to be recorded will include habitat type, weather, sex (for adults), behavior, species, and whether the observation was through visual or audio means. Night surveys will also be conducted. Taped recordings of suspected owls will be used to elicit responses. Field teams will maintain qualitative records of birds observed while conducting other activities during the field investigations. The data collected will be used to estimate species richness, density, and habitat use. Additionally, all active nests found during the investigation will be documented. Particular attention will focus on surveys for listed species or other species of special concern.

Quality control, quality assurance, and chain-of-custody procedures will be followed throughout all stages of biotic sample and data collection. Detailed QA/QC procedures will also be provided in any subcontractor's field sampling plan.

A.6.2 Physical Media Sampling

The QAPP and the field sampling plan provide information on the technique, location, type, extent, and duration of the physical media sampling to be conducted at the site. The purpose of the field sampling plan is threefold: (1) to verify, refute, or modify the current conceptual model of the site contamination processes; (2) to determine the nature and extent of contamination at each contaminated area at the site; and (3) to identify pathways of contaminant location. The field sampling plan provides all details on sample numbers, data quality objectives, and sample locations. The QAPP contains requirements for sampling.

A.6.3 Reference Area

All sampling, data collection, and media handling procedures used at the site will be followed at the reference locations. To the extent possible, sampling will be in parallel. This parallel sampling will be a major factor in determining the number of field personnel required.

A.7 QUALITY ASSURANCE, QUALITY CONTROL, AND CHAIN-OF-CUSTODY PROCEDURES

Many of the QA/QC and chain-of-custody procedures will follow those outlined in the QAPP (BPV 1993b). Appendix C provides an annotated outline of the QAPP. The following sections reiterate the more salient points regarding the QA/QC and chain-of-custody procedures.

A.7.1 Quality Assurance Measures

The EPA requires all of its laboratories, program offices, and regional offices to participate in a QA program. This applies to all environmental sampling, monitoring, and measurement efforts supported by the EPA or mandated through contracts, regulations, and/or formal agreements. The EPA recommends that a formal QA plan be developed for all data-generating activities associated with ecological assessments at hazardous waste sites (EPA 1989a).

The QA measures identified in this work plan include all aspects of laboratory and field procedures that affect the accuracy and precision of the data, including the collection and handling of soil, sediment, and biological samples; the source and condition of all test organisms; the condition of all sampling and test equipment; instrument calibration; sample replicates and controls; record keeping; and data analysis and evaluation. The QA procedures include the maintenance of chain-of-custody, collection of QA samples, and the documentation of collection and analytical procedures.

Additional, more detailed and separate QA procedures will be developed for all subcontractor activities (laboratory and field), and these procedures will be submitted and reviewed before any portion of this ecological risk assessment plan is initiated. The appropriate data QA/QC measures will be followed, as outlined in Appendix C.

A.7.2 Data Management

Data collected as part of the ecological risk component of the site focused RI/FS will be stored in the Installation Restoration Data Management System or in the Biological/Ecological Database Management System being developed to support the site bioassessment work. The database management system for ecological studies is described in the quality assurance project plan (BPV 1993b).

A.8 TECHNICAL SUPPORT AND FACILITIES

Subcontractors will be employed to perform field sampling and laboratory analyses. These subcontractors will be required to prepare an approved work plan (including QA/QC procedures). Additional support, in the form of physical space at the site for investigators and other personnel and necessary capital, will be required for the efficient completion of this ecological risk assessment.

A.9 REFERENCES[9]

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[9] All references are citations of actual publications, except those bracketed. Those are fictitious citations created for the work plan example.

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